Chapter 5, Solution 34

$$\frac{v_1 - v_{in}}{R_1} + \frac{v_1 - v_{in}}{R_2} = 0 \qquad (1)$$

but

$$v_a = \frac{R_3}{R_3 + R_4} v_o \qquad (2)$$

Combining (1) and (2),

$$v_1 - v_a + \frac{R_1}{R_2} v_2 - \frac{R_1}{R_2} v_a = 0$$

$$v_a\left(1 + \frac{R_1}{R_2}\right) = v_1 + \frac{R_1}{R_2} v_2$$

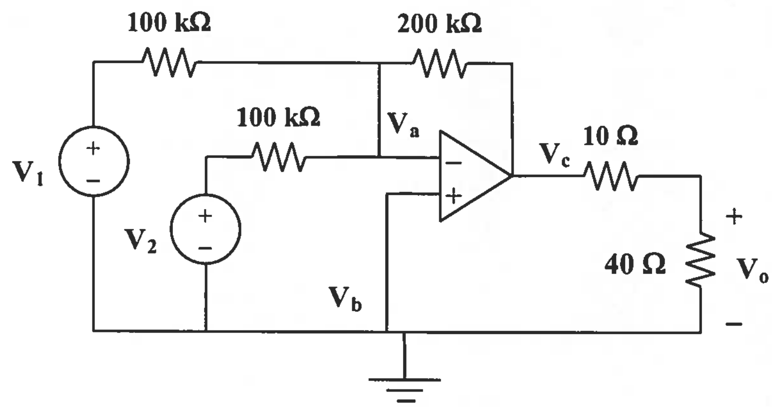
$$\frac{R_3 v_o}{R_3 + R_4}\left(1 + \frac{R_1}{R_2}\right) = v_1 + \frac{R_1}{R_2} v_2$$

$$v_o = \frac{R_3 + R_4}{R_3\left(1 + \frac{R_1}{R_2}\right)}\left(v_1 + \frac{R_1}{R_2} v_2\right)$$

$$v_O = \underline{\boldsymbol{\frac{R_3 + R_4}{R_3(R_1 + R_2)}(v_1 R_2 + v_2)}}$$

Chapter 5, Solution 40

Determine V_o in terms of V_1 and V_2.



Step 1. Label the reference and node voltages in the circuit, see above. Note we now can consider nodes a and b, we cannot write a node equation at c without introducing another unknown. The node equation at a is $[(V_a - V_1)/10^5] + [(V_a - V_2)/10^5] + 0 + [(V_a - V_c)/2x10^5] = 0$. At b it is clear that $V_b = 0$. Since we have two equations and three unknowns, we need another equation. We do get that from the constraint equation, $V_a = V_b$. After we find V_c in terms of V_1 and V_2, we then can determine V_o which is equal to $[(V_c - 0)/50]$ times 40.

Step 2. Letting $V_a = V_b = 0$, the first equation can be simplified to,

$$[-V_1/10^5] + [-V_2/10^5] + [-V_c/2x10^5] = 0$$

Taking V_c to the other side of the equation and multiplying everything by $2x10^5$, we get,

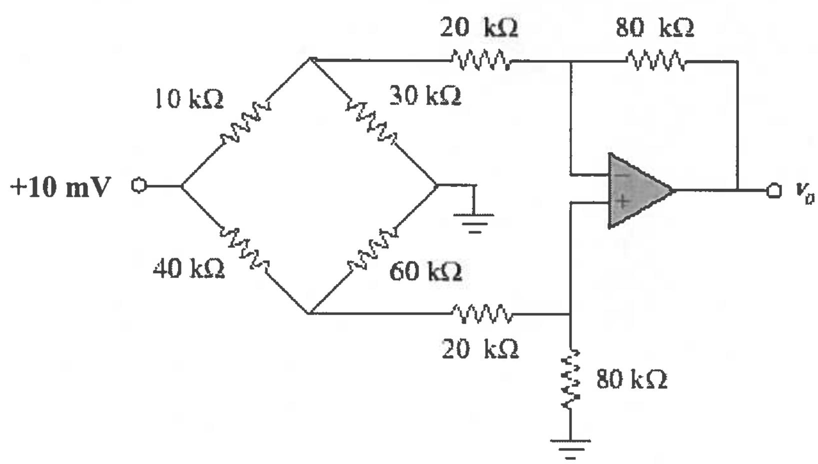
$$V_c = -2V_1 - 2V_2$$

Now we can find V_o which is equal to $(40/50)V_c = 0.8[-2V_1 - 2V_2]$

$$\mathbf{V_o = -1.6V_1 - 1.6V_2.}$$

Chapter 5, Solution 48.

We can break this problem up into parts. The 5 mV source separates the lower circuit from the upper. In addition, there is no current flowing into the input of the op amp which means we now have the 40-kohm resistor in series with a parallel combination of the 60-kohm resistor and the equivalent 100-kohm resistor.



Thus, $40k + (60x100k)/(160) = 77.5k$

which leads to the current flowing through this part of the circuit,

$$i = 10\ m/77.5k = 129.03x10^{-9}\ A$$

The voltage across the 60k and equivalent 100k is equal to,

$$v = ix37.5k = 4.839\ mV$$

We can now calculate the voltage across the 80-kohm resistor.

$$v_{80} = 0.8x4.839\ m = 3.87\ mV$$

which is also the voltage at both inputs of the op amp and the voltage between the 20-kohm and 80-kohm resistors in the upper circuit. Let v_1 be the voltage to the left of the 20-kohm resistor of the upper circuit and we can write a node equation at that node.

$$(v_1 - 10m)/(10k) + v_1/30k + (v_1 - 3.87m)/20k = 0$$

or $$6v_1 - 60m + 2v_1 + 3v_1 - 11.61m = 0$$

or $$v_1 = 71.61/11 = 6.51 \text{ mV.}$$

The current through the 20k-ohm resistor, left to right, is,

$$i_{20} = (6.51m - 3.87m)/20k = 132 \times 10^{-9} \text{ A}$$

thus, $$v_o = 3.87m - 132 \times 10^{-9} \times 80k = \mathbf{-6.69 \text{ mV}}.$$

Chapter 5, Solution 62.

Let v_1 = output of the first op amp
v_2 = output of the second op amp

The first stage is a summer

$$v_1 = -\frac{R_2}{R_1}v_i - \frac{R_2}{R_f}v_o \tag{1}$$

The second stage is a follower. By voltage division

$$v_o = v_2 = \frac{R_4}{R_3 + R_4}v_1 \longrightarrow v_1 = \frac{R_3 + R_4}{R_4}v_o \tag{2}$$

From (1) and (2),

$$\left(1 + \frac{R_3}{R_4}\right)v_o = -\frac{R_2}{R_1}v_i - \frac{R_2}{R_f}v_o$$

$$\left(1 + \frac{R_3}{R_4} + \frac{R_2}{R_f}\right)v_o = -\frac{R_2}{R_1}v_i$$

$$\frac{v_o}{v_i} = -\frac{R_2}{R_1} \cdot \frac{1}{1 + \frac{R_3}{R_4} + \frac{R_2}{R_f}} = \frac{-R_2R_4R_f}{R_1(R_2R_4 + R_3R_f + R_4R_f)}$$

Chapter 5, Solution 78.

The circuit is constructed as shown below. We insert a VIEWPOINT to display v_o. Upon simulating the circuit, we obtain,

$$v_o = \mathbf{667.75\ mV}$$